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August 11, 1998

EX PARTE OR LATE FILED

Ms. Magalie Roman Salas
Secretary
Federal Communications Commission
Room 222
1919 M Street N.W.
Washington, D.C. 20554

EX PARTE

Re: CC Docket Nos. 96-45 and 97-160

Dear Ms. Salas:

I am writing on behalf of the Minnesota Department of Public Service (Department). In connection with a generic cost proceeding for U S WEST Communications, Inc. in Minnesota, the Department prepared and filed testimony relating to the adequacy of the distribution plant deployed by HAI 5.0a model. This issue was originally brought to our attention by an ex parte filing with your office made by Sprint in April of 1998.

Attached is the testimony of Department witness Mr. Wes Legursky. The Department requests this letter together with the attached testimony be made a part of the record in this proceeding. If there are any questions, please call.

Sincerely,

J. Jeffery Oxley

J. JEFFERY OXLEY
Assistant Attorney General

(651) 296-5671 (Voice)
(651) 296-1410 (TTY)

JJO:kkw

cc: Chuck Keller (w/enclosures)

AG:144738 v1

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RECEIVED
AUG 14 1998
FCC MAIL ROOM

June 16, 1998

The Honorable Steve M. Mihalchick
Administrative Law Judge
Office of Administrative Hearings
100 Washington Square, Suite 1700
Minneapolis, Minnesota 55401-2138

Re: In the Matter of a Generic Investigation of the U.S. West Communications, Inc.'s Cost of Providing Interconnection and Unbundled Network Elements
MPUC Docket No. P442,5321,3167,466,421/CI-96-1540
OAH Docket No. 12-2500-10956-2

Dear Judge Mihalchick:

Enclosed for filing, please find the Supplemental Testimony and Exhibit of Wes Legursky and the Comments of Edward Fagerlund on behalf of the Department of Public Service. Also enclosed is an affidavit of service.

Respectfully submitted,

J. Jeffery Oxley

J. JEFFERY OXLEY
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Telephone: (612) 296-5671

COUNSEL FOR THE MINNESOTA
DEPARTMENT OF PUBLIC SERVICE

Enc.
c(w/ enc.): All Parties of Record

STATE OF MINNESOTA)
) ss
COUNTY OF RAMSEY)

AFFIDAVIT OF SERVICE

I, **Linda Chavez**, being first duly sworn, deposes and says:

That on the **16th** day of **June, 1998**, she served the attached **Supplemental Testimony and Exhibit of Wes Legursky and the Comments of Edward Fagerlund on behalf of the Department of Public Service**

Docket Numbers: **P442,5321,3167,466,421/CI-96-1540**

by depositing in the United States Mail at the City of St. Paul, a true and correct copy thereof, properly enveloped with postage prepaid.

X by personal service

X by express mail

X by delivery service

to all persons at the addresses indicated below or on the attached list:

Linda Chavez

Subscribed and sworn to before me

this 16th day of June, 1998

Karen L. Santori

KAREN L. SANTORI
NOTARY PUBLIC - MINNESOTA
My Comm. Exp. Jan. 31, 2000

Schedule 3 of the Exhibit to the Supplemental Testimony of Wes Legursky contains' seventeen color maps. A "C" on the service list indicates a color copy was served. A "B" indicates a black and white copy was served.

P442,5321,3167,466,421/CI-96-1540

C-2 B-7
Burl W. Haar, Exec Sec
MN Public Utilities Commission
350 Metro Square Bldg
121 7th Place East
St. Paul, MN 55101

C-1 B-3
Linda Chavez (4)
MN Dept of Public Service
200 Metro Square Bldg
121 7th Place East
St. Paul, MN 55101

C-1 B-1
Steve Mihalchick
Administrative Law Judge
Office of Admin Hearings
100 Washington Sq, Ste 1700
Minneapolis, MN 55401-2138

C
Ellen Gavin/J. Jeffrey Oxley
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C
Michael J. Shortley, III
Frontier Corporation
180 South Clinton Avenue
Rochester, NY 14646

B
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U S WEST Communications, Inc.
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B
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801 Nicollet Mall
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Joann Anderson
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Minneapolis, MN 55402-3233

B
Kathryn Sheffield
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David G. Seykora
U S WEST Communications, Inc.
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Donald Low
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Kansas City, MO 64114

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Linda Gardner
United Telephone Company
5454 West 110 Street
Overland Park, KS 66211

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James M. Strommen/Daniel L. Greensweig
Kennedy & Graven, Chartered
470 Pillsbury Center
200 South Sixth Street
Minneapolis, MN 55402

B
Amy Klobuchar/Gregory R. Merz
Gray, Plant, Mooty, Mooty & Bennett
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33 South Sixth Street
Minneapolis, MN 55402

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David L. Sasseville
Lindquist & Vennum P.L.L.P.
4200 IDS Center
80 South Eighth Street
Minneapolis, MN 55402-2205

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Kristine L. Eiden
Hatch, Eiden & Pihlstrom
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120 South Sixth Street
Minneapolis, MN 55402

B
Gena M. Doyscher
Frontier Telemanagement, Inc.
1221 Nicollet Mall, Ste 300
Minneapolis, MN 55403

B
Richard J. Johnson/Michael J. Bradley
Moss & Barnett
4800 Norwest Center
90 South Seventh Street
Minneapolis, MN 55402-4129

B
Douglas W. Trabaris
Senior Regulatory Counsel
Teleport Communications Group, Inc
233 South Wacker Dr, Ste 2100
Chicago, IL 60606

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MCI Telecommunications Corp.
707 17th Street, #3600
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B
William E. Flynn/Kimberly S. Freise
Lindquist & Vennum P.L.L.P.
4200 IDS Center
80 South Eighth Street
Minneapolis, MN 55402-2205

INTRODUCTION

Q. Please state your name and business address.

A. My name is Wes Legursky. My business address is 60B West Terra Cotta Avenue, Suite 166, Crystal Lake, Illinois 60014.

Q. What is your current position?

A. I am an independent consultant specializing in telecommunications systems. The Minnesota Department of Public Service retained me to analyze the network models in this case.

Q. Have you previously testified in this proceeding?

A. Yes, I have filed direct, rebuttal and surrebuttal testimony.

Q. What is the purpose of your testimony?

A. In my Supplemental Testimony today, I address information gathered on a site visit to PNR regarding the Minimum Spanning Tree (MST) benchmark and the HAI modeling process.

PNR DATA - MST DATA

Q. What is the minimum spanning tree and what does it measure?

A. The Minimum Spanning Tree (MST) is a heuristic algorithm that attempts to determine the minimum distance required to connect a set of points. By repeatedly applying several rules of thumb, the algorithm seeks to compute a set of lines between a given set of points such that the total length of the lines is minimized.

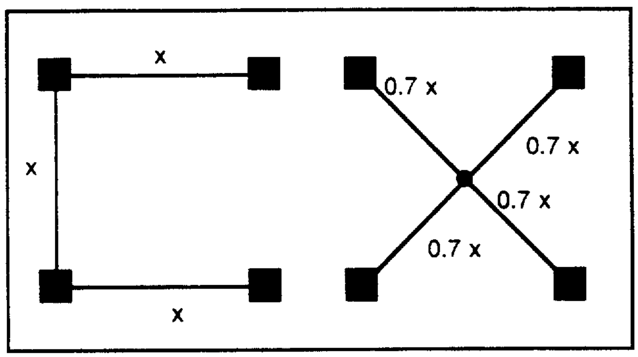
Q. Will the MST always compute the actual minimum length needed to connect a given set of points?

A. There are two issues involved in answering this question. The first issue is whether the MST algorithm always does what it purports to do, that is, calculate the absolute minimum distance connecting a set of points. The second issue is whether the MST is always equal to what I shall call the MTP (Minimum Telephony Plant). The MTP is defined to be the minimum distance that connects a set of points using telephony design. I do not believe that a forward-looking, efficiently designed telephony network should possess a distribution network with a total length equal to the MTP. However, the attention devoted to the MST in this proceeding and in connection with the Sprint ex parte filing with the FCC suggests that certain parties believe distribution lengths should equal the MTP and that the MST is equal to the MTP. For reasons I will explain below, I do not agree.

As to the first issue, I have not been presented with a proof that sets out the specific circumstances under which the MST algorithm is guaranteed to determine the minimum spanning length. In my experience, algorithms of this type often generate adequate answers for many practical purposes but rarely generate answers that are correct under all circumstances.

As to the second issue, the MST algorithm is simple to understand and will always generate the same answer when applied to the same set of points. However, it works only with the set of points given to it. The shortest distance between two points is a straight line. The algorithm uses only straight lines to connect points. The basic task of the MST algorithm is to search for the order in which a given set of points must be connected to minimize the total length of the connecting lines.

The key constraint for the algorithm is that the connecting lines are constructed only between existing points. It is easy to show that this constraint can be significant. That is, by permitting new points to be added from which connecting lines can be extended, it will sometimes be the case that the total length of the connecting lines is less than the minimum length of connecting lines that can be constructed without adding new points. A simple example will illustrate the point. Select 4 points that form the vertices of a square with length and width equal to x. The MST will compute a minimum connecting length of 3x -- it is not necessary to "complete" the square, only connect the points. (see the figure below) If we add an additional point at the center of the square, then the distance to connect all five points is 2.8x (4 * 0.7x = 2.8x). This simple example illustrates that the freedom to add points (such as a Serving Area Interface), makes it possible to connect all locations with lengths shorter than the MST.



A key feature of telephony plant is that cabling in the distribution network will have more nodes than just customer locations. These additional nodes include pedestals, nodes formed by splitting of cable routes, and nodes formed by serving area interfaces.

It is easy to see how the freedom to add additional nodes to a given set of customer locations in situations involving few customer locations may result in total connecting lengths less than the MST. Similar opportunities to reduce cable lengths by adding nodes also exist in denser customer location patterns.

Q. Is the MST or MTP used in normal outside plant planning and design processes?

A. No, neither number is relevant to the normal outside plant planning processes of a telco. Outside plant designs are not judged by comparing the cable lengths involved to the MST or MTP. Engineers make no reference to MST or MTP values in developing their designs. The MST and MTP simply do not provide a relevant or meaningful benchmark against which to compare the cable lengths generated by the cost models submitted in this proceeding: HAI, BCPM, and RLCAP.

Q. What do you believe can be gained by comparing distribution plant lengths within a cluster to MST calculated lengths?

A. Nothing. If telephony plant could not have nodes other than customer locations, then the MST might be a relevant benchmark for assessing each model's distribution plant design. However, telephony plant does permit nodes in addition to customer location. These nodes include pedestals, serving areas interfaces and splitting of a single cable route into multiple routes. The appropriate comparison should be between the Minimum Telephony Plant (MTP) measure and the calculated cable lengths of the each model, including distribution and drop lengths. Unfortunately, I am not aware of any practical algorithm that calculates the MTP, and, as I have explained, I do not believe the MST is a good indicator of the MTP.

Q. Do you believe that the MST is a good indicator of the amount of distribution cable needed?

A. No, I do not. This case is the first time I have encountered the proposition that MST should be used to predict the MTP. This is not because the MST is a new concept or because a satisfactory algorithm for calculating it has recently become available. Analysts have known about MST calculations for a long time. No one however has thought it appropriate to use in the context of assessing outside plant designs because it is a poor predictor of MTP.

Unfortunately, many times a benchmark that initially has significant intuitive appeal does not stand up under more rigorous analysis. For instance, is horsepower a good predictor of top speed? It certainly would seem to be -- you require more horsepower to go faster. Would anyone want to try to beat a 300 hp Corvette with a 600-hp Kenworth truck? While horsepower sounds as though it should be a good predictor of top speed, reality is more complicated. Similarly with telephone plant, the ability to introduce nodes in real world telephone networks makes the calculation of the MTP more complex than the MST. Consequently, the MST should not be considered a significant benchmark against which to assess the HAI model.

Q. If it were shown that MST distances closely approximated actual distribution lengths for specific geographic areas, would you then concede the relevance of the MST as a benchmark for assessing the adequacy of distribution cable generated by the cost proxy models in this proceeding?

A. No. Actual or embedded cable lengths are not good measures of the cable lengths that would be deployed in a scorched node environment using forward-looking technologies. The development of new technologies - for example, fiber cable and DLC - has allowed engineers to design plant for distribution areas quite differently than they have in the past. Equally importantly, decisions engineers made in the past about how to serve an area are not necessarily the same as they would make today because of growth and population movement. Further, the cost models employed in this proceeding have no practical constraints such as budget amounts or past plant placements to limit plant design but these factors certainly have influenced the embedded plant. Finally, the modeling decisions made in a TELRIC model are not the same decisions that engineers would make for a company that is rate of return regulated.

Q. What is your recommendation for how the ALJ and the Commission should resolve the issue raised by the MST analysis and comparison to HAI distribution plant lengths?

A. I recommend that the ALJ and the Commission dismiss the comparison as irrelevant. The parties criticizing the HAI calculated distribution lengths should bear the burden of proving that the MST either equals or closely approximates the MTP. To this point I have not been presented with any such proof, on either a practical or theoretical level.

Q. In the event the ALJ and the Commission nonetheless find the MST comparison informative, have you done further analysis?

A. Yes, in the event any party provides adequate proof of the relevance of the MST, I have compared the MST and the HAI distribution distances.

Q. Can you briefly describe what you have done?

A. Yes. Two files were created and distributed at the end of my visit to PNR -- one for U S WEST wire centers and one for GTE wire centers in Minnesota. These files contained the MST and the diagonal measure for each cluster. (The use of PNR data in these calculations has been authorized by PNR.) I then combined this information with distribution lengths generated by the HAI model. To the distribution lengths I added the total drop lengths in the cluster as drops must be included in measuring the cabling that connects customer locations to the network. I next calculated the ratio of HAI distribution to MST. A ratio less than one indicates that in that cluster, the HAI model deployed less distribution cable than the MST; a ratio greater than one indicates that the HAI model deployed more distribution cable than the MST.

Q. Can you summarize the results of that effort?

A. Yes. The table below lists several key statistical measures for both U S WEST and GTE clusters. The numbers can be thought of as can be thought of as percentages. For example, the average U S WEST cluster has a value of 2.12 that means that the HAI distribution distance was 212 percent of the MST on average.

Statistical Measure (no weighting)	U S WEST Clusters	GTE Clusters
Minimum	0.08	0.11
Maximum	70.92	7.98
Median	2.01	0.77
Average	2.12	0.93
Standard Deviation	2.29	0.64

The table above is derived strictly based on the values of the clusters. That is a cluster with 10 lines has the same weight as a cluster with 1,000 lines. A more representative way to view these statistics is to weight each cluster based on the number of lines it contains. This yields a better representation of how the model performs across the entire network. I present that information below.

Q. Did you look at these numbers at a finer level of detail?

A. Yes. I grouped each of the nine density zones (DZ) and performed analysis at that level. For each DZ, I created a histogram of observations from 0 to 4.0 in increments of 0.20. I also computed the average, standard deviation, minimum value and maximum value of the population of observations. The results of this analysis are found in Schedules 1 and 2 of my exhibit for U S WEST and GTE respectively.

I have provided a summary table for U S WEST's Minnesota territory below. Columns A and B define the density zones. Columns C through G provide the minimum value, maximum value, average value, standard deviation and median, respectively. Column H lists the percentage of cluster ratios that are less than 1.00 and column I lists the percentage of cluster ratios over 3.00.

Statistical Summary Table -- U S WEST Data

A	B Range	C Min	D Max	E Avg	F StdDev	G Median	H <1.0	I >3.0
DZ1	0-5	0.09	7.97	0.77	0.53	0.67	17.6%	1.1%
DZ2	5-100	0.14	9.74	1.11	0.69	0.93	17.9%	1.5%
DZ3	100-200	0.28	6.61	2.24	0.97	2.14	4.7%	18.7%
DZ4	200-650	0.34	6.48	2.45	0.88	2.42	2.0%	24.8%
DZ5	650-850	0.14	4.17	2.60	0.89	2.62	4.7%	27.7%
DZ6	850-2550	0.12	70.92	2.77	3.05	2.53	0.0%	23.6%
DZ7	2550-5000	0.08	10.69	2.91	0.92	2.76	0.0%	36.6%
DZ8	5000-10000	0.81	63.09	3.33	4.22	2.87	0.9%	44.4%
DZ9	>10,000	0.61	29.68	3.96	3.53	3.02	1.3%	51.1%
All	---	0.08	70.92	2.12	2.29	2.01	28.3%	19.5%

Q. What do you conclude from these observations?

A. First, the variation in the data is quite high as indicated by the fact that the average is 2.12 and the standard deviation is 2.29. That indicates that the data has a very wide "spread."

Second, the means consistently increase from the lowest density to higher density zones. However, in all DZs there are both very large maximum and very small minimum values. This indicates that the phenomenon we are observing appears in all density zones not just the lowest two.

Third, I do not recommend making an adjustment because there is no foundation on which to believe the MST is equal to the MTP. If, nonetheless, the Commission decides the MST is a good indicator of the MTP, and that the MTP is itself a valuable indicator of the minimum amount of distribution cabling, it may order adjustments to the model. Consistency would then require that if adjustments to the model are made to correct for deploying too little cable in the least dense zones, there similarly be adjustments in the higher density zones where too much cable is deployed. If we are to accept that the MST is somehow a reasonable indicator of the amount of distribution cable that should be deployed in a forward-looking, least-cost network, then the HAI model should have an adjustment, which, on balance across all density zones, actually decreases the amount of distribution plant deployed.

The last two columns of the table show that the HAI model deploys cable lengths in excess of 3.0 times the MST less frequently than it deploys cable lengths less than the MST. In fact, 28.3 percent of the clusters are below 1.0 while 19.5 percent are above 3.0. However, when these clusters are weighted by the number of lines they contain, the impact of the areas where less cable than the MST amount is deployed is quite small as shown in the table below. Only 1.5 percent of the lines are found in clusters having less distribution plant than the MST while over 45 percent of lines are in clusters having over three times as much distribution plant as the MST.

U.S WEST Data - Line Counts

	Cluster Count	Percentage of Clusters	Line Count	Percentage of Lines
< 1.0	889	28.3%	39,652	1.5%
> 3.0	779	19.5%	1,216,418	45.7%

Q. Did you perform similar statistical analysis based on wire center level groupings?

A. Yes. As I stated earlier, this gives a much better indication of the impact of any purported underbuilding -- or overbuilding. The following table lists the simple statistics used above for the clusters. However, in this case the data has been weighted for the number of lines and aggregated at the wire center level. As the table indicates, the variability of the data is much reduced (standard deviation is 1.11 vs. 2.29) indicating this measurement has eliminated considerable "noise" in the data. Also, the mean has increased 14 percent from 2.12 to 2.42.

Statistical Measure (weighting on lines)	U S WEST Wire Centers	GTE Wire Centers
Minimum	0.67	0.60
Maximum	9.04	5.07
Median	2.34	1.27
Average	2.42	1.39
Standard Deviation	1.11	0.58

Q. Did you perform similar analysis for GTE clusters and wire centers?

A. Yes, I did. That information is attached as Schedule 2. For the sake of brevity, I will not discuss that data at the same level of detail. The trends tend to be the same for GTE wire centers and clusters. The distribution of ratios is skewed more towards zero due to the fact that GTE has a much higher percentage of less dense clusters. In fact, only 51 of 892 clusters are in density zones 3 and higher. Almost the entire population of clusters is in density zones one and two.

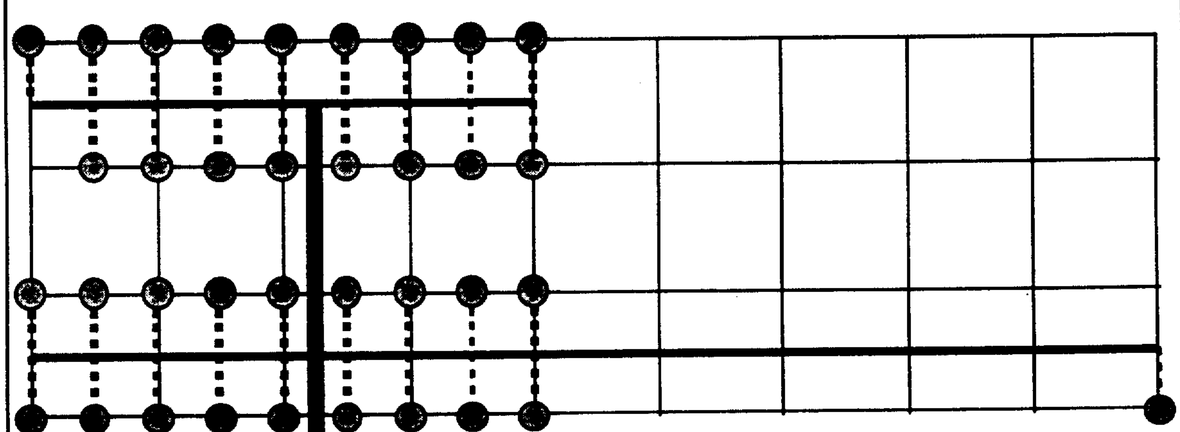
Q. Do you think the HAI model contains adequate costs for distribution cable?

A. Yes. The value of the MST is only a single indicator of cable length and it appears to be a poor one. I have reviewed the HAI geolocation process and the results it achieves. Following my onsite visit to PNR and my subsequent analysis, I am more convinced than ever that the HAI geolocation process and its surrogate methodology is superior to the methods used in BCPM and RLCAP. Further, the HAI is conservative in its surrogate customer placement methodology. The Department selected three wire centers that it considered to be roughly representative of rural, suburban and urban wire centers. The points, clusters and Census Block (CB) boundaries for these wire centers were plotted and printed. These pictures are presented as Schedule 3.

Q. How could the HAI model overestimate the amount of distribution plant needed in a cluster?

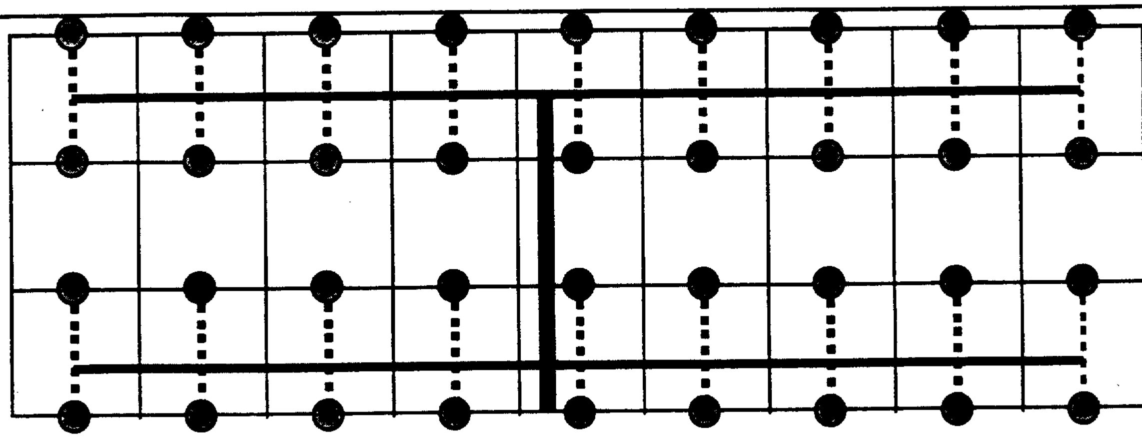
A. As I reviewed the cluster data graphically, I became aware of a phenomenon that I will call "clustering within clusters." By this term I mean that many clusters have one or more smaller clusters of customer locations within them. There is often a relatively large percentage of vacant or unpopulated land within a cluster. Since the HAI model uniformly distributes customers within a cluster, the net effect is to move customers farther apart than they really are and thus to calculate that more cable is necessary to connect them to the network than would be actually needed.

The two figures below illustrate this point. In the first figure, the horizontal cables measure 800 and 1800 feet and the vertical backbone cable measures 500 feet. The total distribution less drops in this case is 3100 feet. The drop lengths are ignored in this example because they are the same in both cases.



- Each grid size is 200'.
- Dotted lines represent drops.

In the second figure, the locations have been uniformly distributed across the area simulating the HAI modeling process. In this case, additional cable is required to connect all the points. Both horizontal cables now measure 1600 feet each and the vertical backbone cable remains at 500 feet. The total in this case is 3700 feet or almost 20 percent more than in the initial configuration.



- Each grid size is 200'.
- Dotted lines represent drops.

This clearly illustrates that the HAI process of redistributing customers evenly across the serving area cluster developed by the HAI model from the small clusters in which they are actually located results in additional cable being placed.

Q. Are you familiar with the criticism of the HAI model's method of placing non-geocoded customers uniformly around the appropriate census block boundary?

A. Yes, the criticism has been made that that surrogate location process artificially reduces costs because customers from different census blocks are placed on the boundaries between them, thereby providing a basis for forming a cluster that does not, in reality, exist. I do not accept that criticism however because only rarely does it appear that clusters are formed that solely contain surrogate points on census block boundaries.

Q. So on balance, is it your opinion that the HAI methodology overstates or understates distribution costs?

A. In toto, I believe the HAI model fairly estimates distribution costs. With respect to distribution cabling, if HAI errs, it errs on the side of overstating costs, but not to an extent that raises a significant concern for me.

MAPINFO WIRE CENTER OUTPUT

Q. Please describe the wire centers and the slides you have taken of the data that the Department selected to examine in detail.

A. The slides were created using the application MapInfo and the PNR data. Each of three wire centers has an initial slide that depicts the entire wire center and then highlights the areas that are found in later detail slides. The following is a brief discussion of each of the slides. They appear as Schedule 3 to this testimony.

<u>Slide 1: Biwabik Wire center</u>

Biwabik is a rural wire center. This slide provides a view of all five clusters in the Biwabik wire center. There are six additional slides of the same data that were taken at a higher level of resolution. The approximate areas shown in these detail slides are indicated by the dotted line rectangles.

<u>Slide 2: Biwabik #1</u>

This slide depicts the northernmost cluster in the wire center. It is composed entirely of surrogates. Seven of the surrogate points have been highlighted with dotted line circles. These seven points are the outermost points -- the lines connecting these points create the convex hull that is referenced in the HAI documentation.

It is quite easy in this picture to see that the surrogate points are located along Census Block boundaries which are indicated by the thin black line. Looking along the northern part of the cluster, several surrogate points can be seen evenly placed along the boundary.

The center of the cluster contains a large number of surrogate residence data points. The CBs are quite small and each contains about ten to fifteen customer locations. This area appears to be a hew housing development that has census block counts but no mass mailing database information as yet. A later slide seems to support this hypothesis as the boundaries also coincide with roads or streets.

Slide 3: Biwabik #2

This slide depicts the central cluster at a slightly smaller scale. Several areas of concentration (indicated by the arrows) are found in this cluster. As is readily seen here, a cluster often has smaller clusters of customers within it. After the convex hull is determined, an equivalent area rectangle is created. The customers are then uniformly spread throughout this area.

The overall effect of the HAI process would separate these customers from one another much more than they are in reality. This, in turn, causes more costs to be computed. This supports the HAI claim that the clustering process is conservative.

Slide 4: Biwabik #3

This slide is a detail view of the southernmost cluster. It is interesting because even in this very sparsely populated area, all but two business locations have been geolocated. The arrows indicate these two un-geocoded locations.

Slide 5: Biwabik #4

This slide depicts the Census Block Boundaries in blue and roads in black. This is useful in illustrating the relationship between roads and census block boundaries. They often coincide.

Slide 6: Biwabik #5

This slide also illustrates the relationship between roads and census block boundaries. It details the area covered by the northernmost cluster.

Slide 7: Biwabik #6

This is a very detailed view of the "new development" area in the northernmost cluster. It has both roads and CB boundaries indicated. Again a very close correlation between the two is observed. Also, note that the HAI clustering algorithms have the net effect of placing customers on roads. In this example, the clustering algorithms have resulted in excellent placement of surrogate points.

Slide 8: Biwabik #7

Borderlines and roads obscured many of the surrogate points on the north/south streets in the previous slide. This slide removes both the CB boundaries and roads so that a good view of all surrogate points is obtained.

Slide 9: Cottage Grove Wire center

Cottage Grove is a suburban wire center. This slide provides a view of all 19 clusters in this wire center. There are four additional slides of the same data that have been taken at a higher level of resolution. The approximate locations of these slides are shown by the dotted line rectangles.

Slide 10: Cottage Grove #1

This slide is a slightly larger scale of the central part of the wire center. It is quite easy to see the streets and blocks of a suburban wire center. Also, it is interesting to note where the business zones are along certain streets.

Slide 11: Cottage Grove #2

This is a more detailed view of the rectangular cluster in the left-center area. This is an excellent representation of the large amounts of vacant land that can be found in many clusters. The customers are heavily concentrated in the southwest corner and the eastern side of the cluster. The cluster appears to be 60-75 percent vacant. The HAI clustering algorithms in this case would certainly result in conservative (higher) costs.

Slide 12: Cottage Grove #3

This slide is a detailed view of the two clusters in the north west corner of the wire center. Both of these clusters contain significant amounts of vacant land. However, the customer locations are generally uniformly distributed throughout the cluster. In these cases, the HAI clustering algorithms produce excellent results.

Slide 13: Cottage Grove #4

This slide is a very detailed view of one of the central clusters. It illustrates how the geolocation process has actual locations off the street and surrogate locations, in effect, in the middle of streets. This occurs because of the high correspondence between streets and CB boundaries. This does not cause me concern because the error from actual locations is quite small compared to the overall distances involved.

Slide 14: North St. Paul Wire center

North St. Paul is an urban wire center picked at random by the DPS. This slide provides a view of all twenty-nine clusters in this wire center. There are three additional slides of the same data that has been taken at a higher level of resolution. The approximate locations of these slides are shown by the dotted line rectangles.

Slide 15: North St. Paul #1

This slide indicates that even in very dense urban areas, clusters can have significant amounts of undeveloped or vacant area. Again, the HAI algorithms result in conservative placement of customer locations.

Once the location of points is completed, the clustering algorithm works independently from CB boundaries, as indicated by the arrows on the right side of this slide. In this case, it is apparent that a CB boundary is running north to south and crosses two cluster boundaries. The surrogate points are placed evenly along the CB boundary. This occurs from both adjacent CBs. The geolocated points all appear to be on the southern part of this street. This is quite likely where all the surrogate points are in reality as well. However, the HAI process provides a conservative spreading of the customers.

Slide 16: North St. Paul #2

In this slide, the arrows indicate where surrogate customers have been placed along the boundary of the Census Blocks. They are placed quite a distance from the cluster of geolocated points in the area indicated by A. Many of the surrogate points are probably in reality in or near the area A. The conservative effect of placing the surrogates on CB boundaries is evident here.

Slide 17: North St. Paul #3

This is a detailed view of the clusters in the left-center area of the wire center. It also indicates that there are significant empty areas in each cluster. These four clusters are all very rectangular and have areas of about one-half a square mile each. The HAI algorithm would be excellent in approximating distribution costs in these areas.

Q. What do you conclude from these wire center pictures regarding the geolocation process?

A. The geolocation process works very well and will only get better with time as increasing percentages of customer locations are geocoded. Geocoding is much superior to estimating where customers are located based on the center of mass of roads as done in BCPM.

CONCLUSION

Q. Should the HAI model be dropped in favor of RLCAP or BCPM?

A. Absolutely not! This process of analyzing the HAI model in depth should not be construed in any way to mean that the HAI model is inferior to RLCAP or BCPM.

RLCAP simply has no capability whatsoever to approach this level of detailed modeling. RLCAP works with embedded feeder lengths. Distribution cable lengths can be determined from density group designs, but the deployment of these designs is not based on actual customer locations. Rather, these designs are deployed solely on the basis of the wire center group the wire center belongs to.

RLCAP does not map customer locations into discrete serving areas. Although an estimate of the length of distribution cable "deployed" by RLCAP in a given wire center can be made, that amount is strictly a function of the wire center group the wire center belongs to times the number of lines in that wire center. If U S WEST wishes to criticize the HAI model for the amount of distribution plant it deploys relative to the MST and use this as a reason for the Commission to select RLCAP, the Company should be required to prove that RLCAP's implied distribution lengths better approximate the MST, either by serving area or by wire center.

BCPM also does not model costs based on actual customer locations.

BCPM uses a surrogate process that assumes customers are evenly located within 500 feet of certain roadways. This road area is then converted to a road-reduced area located in the road centroid of the quadrant. In BCPM distribution costs will vary with the size of the road boundary and the ratio of road mileage in the grid to customer numbers. These costs will also vary depending upon the location of the grid itself. The road boundary assumption of 500 is not supported nor is the assumption that customers are spread evenly along the roadways. The placement of the grid itself is entirely arbitrary. The assumptions about customer location, road width and size of the road-reduced area do permit BCPM to calculate a length of distribution plant. However, it is very difficult to see why analytically that BCPM's result should bear any close relationship to the amount of distribution plant needed to serve customers at their actual locations.

If U S WEST believes the MST is a valid benchmark for distribution plant, the amount of distribution plant in BCPM should be compared to the MST as well.

In this proceeding, the HAI model has been given extra scrutiny that has not befallen the BCPM model. It is important to recognize that this extra level of scrutiny does not imply the HAI model is inferior in any way to BCPM. It simply means that we have performed more analysis on the HAI model because it is the Department's recommended model. If BCPM were subjected to this level of additional analysis, many more issues with it would have been uncovered.

HAI is much superior to BCPM or RLCAP; it remains my recommendation to adopt the HAI model.

Q. Would you recommend any adjustments in the lower two density zones?

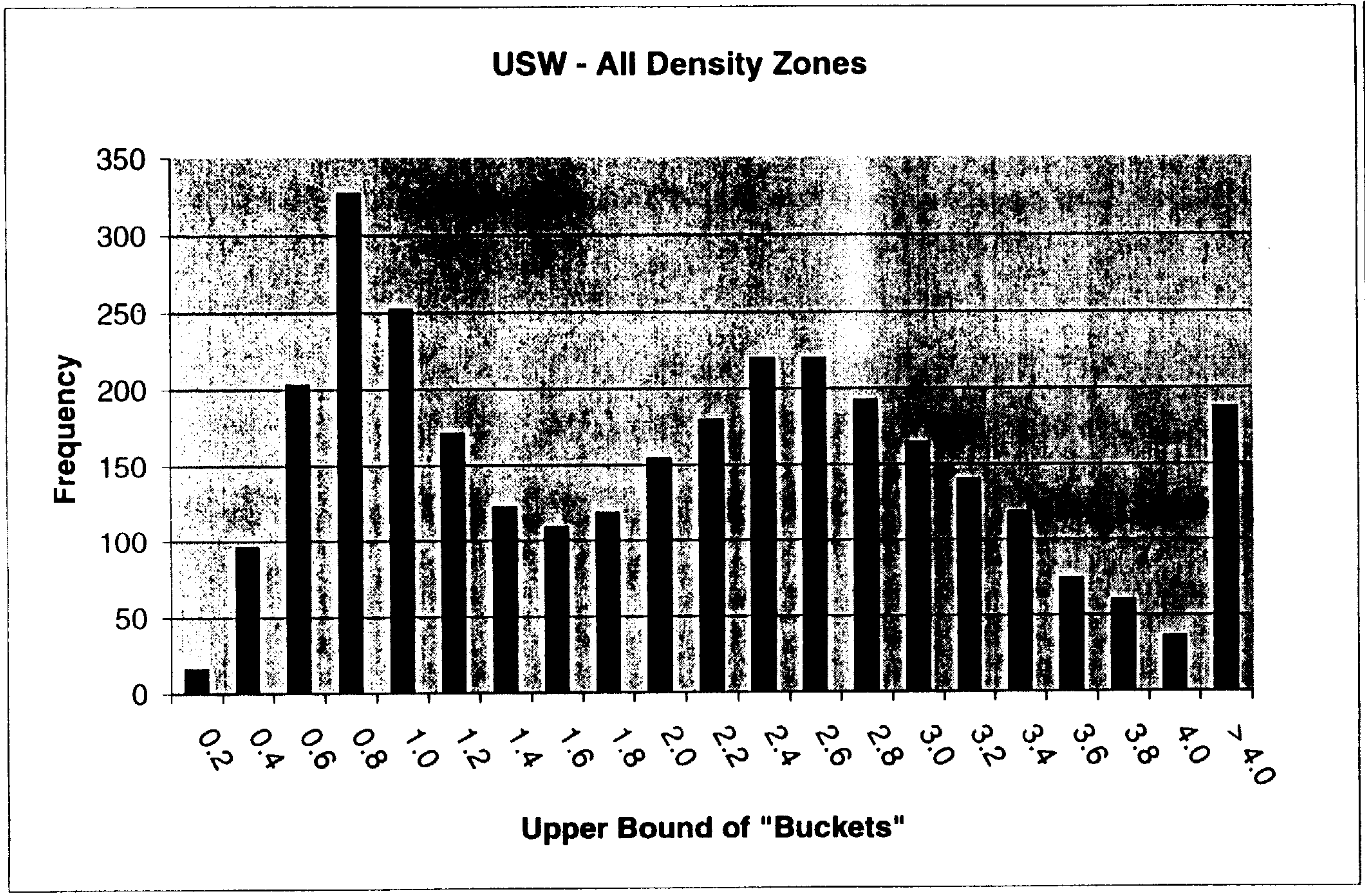
A. No, I would not. I have three concluding points:

1. The MST is simply not a relevant benchmark against which to assess the amount of distribution plant deployed by a model.
2. However, if the ALJ or the Commission determines the MST is relevant, logically and empirically it is just as relevant to the most dense zones as it is to the least dense zones. If an upward adjustment in distribution plant is made in the least dense lower two zones, a downward (and probably larger) adjustment needs to be made in the other seven more dense zones. It would be wrong to address deviations only in the least dense zones. Deviations both upward and downward should be addressed.
3. Further, if the ALJ or the Commission wish to scrutinize the amount of distribution plant so strictly, they should also address the overstatement of plant that results from the fact that customers are clustered within clusters rather than spread uniformly throughout the whole cluster. This may be a more significant adjustment than the adjustment of distribution plant to MST amounts.

In conclusion, the HAI model provides a conservative estimate (i.e., more costly) of distribution cost due to this phenomenon of clustering within clusters. Cost proxy models approximate reality; they do not exactly mirror reality. The HAI model is superior to RLCAP and BCPM as a cost proxy model and I do not believe that any adjustments to the model's calculated distribution plant are necessary.

Q. Does this conclude your testimony?

A. Yes, it does.



All Density Zones

Upper Bound	Count	Percent	Cum Percent
0.2	16	0.5%	0.5%
0.4	96	3.0%	3.5%
0.6	203	6.4%	10.0%
0.8	327	10.4%	20.3%
1.0	252	8.0%	28.3%
1.2	171	5.4%	33.7%
1.4	122	3.9%	37.6%
1.6	109	3.5%	41.0%
1.8	118	3.7%	44.8%
2.0	154	4.9%	49.7%
2.2	179	5.7%	55.3%
2.4	220	7.0%	62.3%
2.6	220	7.0%	69.3%
2.8	192	6.1%	75.3%
3.0	164	5.2%	80.5%
3.2	140	4.4%	85.0%
3.4	118	3.7%	88.7%
3.6	74	2.3%	91.0%
3.8	60	1.9%	92.9%
4.0	36	1.1%	94.1%
> 4.0	187	5.9%	100.0%
	3,158	100.0%	

Min	Max	Median	Average	StdDev
0.08	70.92	2.01	2.12	2.29

The use of PNR data in these calculations has been authorized by PNR.